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THE STRATEGY OF SIMULATION EFFECT OF THE WATER FLOWRATE, TURBINE TYPE, AND ITS INTERACTION TO THE POWER GENERATED BY MHPP

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ABSTRACT

The demand of Indonesian energy is growing faster and the non-renewable energy has decreased very rapidly, so the government tries to explore for an alternative energy to prevent future scarcity of energy resources. One alternative used is to utilize water energy. Water is one of the most renewable and environmental friendly energy, so it has the potential to reduce dependence on current energy usage (petroleum, oil, gas, and coal). The purpose of this research is to simulate effect of turbine type and water flowrate to the power generated by Micro Hydro Power Plants (MHPP). The research method uses experimental design with null hypothesis: there is no effect of turbine type to the power generated by water turbine and there is no effect of water flow rate to the power generated by MHPP. There are two types of MHPP, namely Pelton and Crossflow types. The research result rejected the null hypothesis, it means that there is an effect of turbine type to the power generated by water turbine and there is an effect of water flowrate to the power generated by water turbine.

KEYWORDS: Pelton, Crossflow, Water Flowrate, MHPP, Water Energy & Power

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Original Article

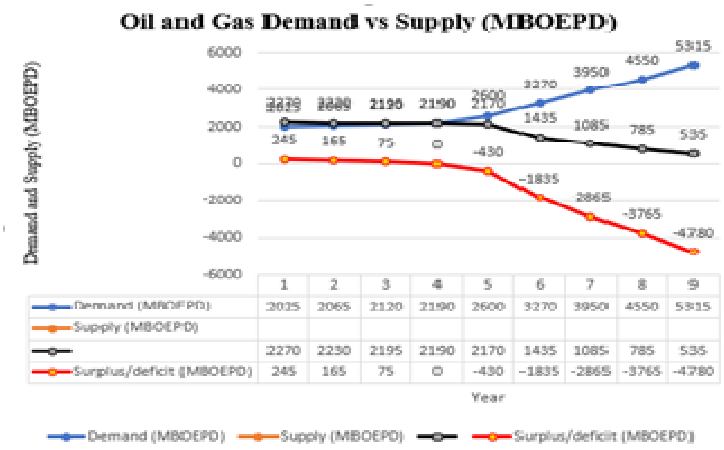
1. RESEARCH BACKGROUND

National energy (fossil energy/non-renewable energy and non-fossil energy/renewable energy) demand is increasing dramatically The gap between supply and demand of energy has become wider and wider as shown in figure 1. It means that the import of energy will increase and at the same time the energy subsidy also increases.

In fact, the Government has already anticipated to decrease the energy subsidy and to increase the power availability and the number of customers (figure 2). Figure 3 shows the increasing power availability from 83 .893 GW in the year of 2012 to become 122.019 GW in the year of 2017.

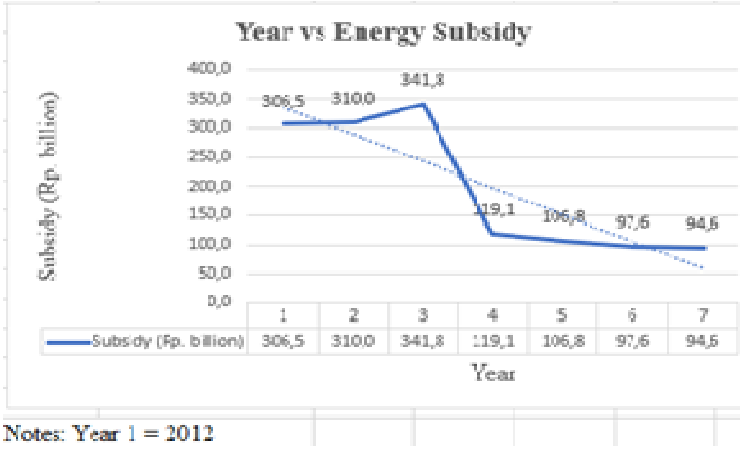
In addition, the government designed the crash program for the construction of the power plants in the year of 2016 till 2019 with total capacity of about 35.000 MW (mega watt) and has already signed the MOU (Memorandum of Understanding) with international and national investors for contructing the power plant up to 31.172 GW at the end of the year 2017. Another important thing is the need of green and clean energy while decreasing the gas emission (COx, NOx, dan SOx) that is produced by the manufacturing industries, households, commercial buildings, and public transportaion system.

The objective of this research is to simulate effect of turbine type and water flowrate to the power generated by Micro Hydro Power Plants.



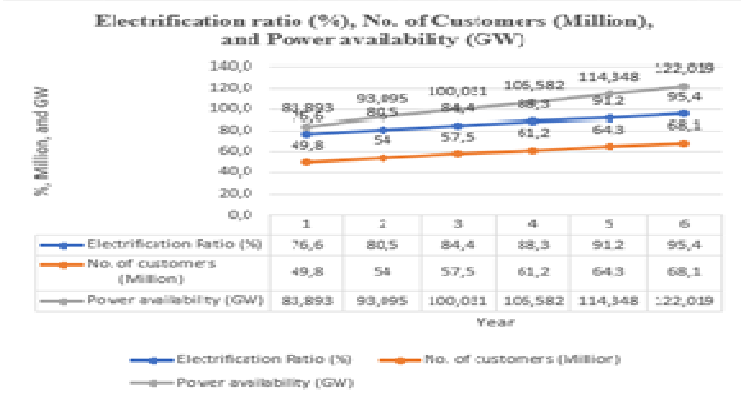
Source: [2], [9].

Figure 1: Energy Supply vs demand (1=2012, 2= 2013, 3=2014, 4=2015, 5=2020, 6=2025, 7=2030, 8=2040, 9=2050).



Source: [2], [9]

Figure 2: Year vs Energy Subsidy.



Notes: Year 1 = 2012

Source: [3], [9]

Figure 3: Electrification Ratio (%), No. of Customers (Million), and Power Availability (GW).

2. LITERATURE STUDY

2.1. Hydraulic Turbines

The impulse turbine (Pelton wheel) is a tool in which the complete drop in stress of the fluid takes area in an unmarriedor extra desk bound nozzles and there may be no change inside the pressure of fluid as it flows through the rotating wheel [4].

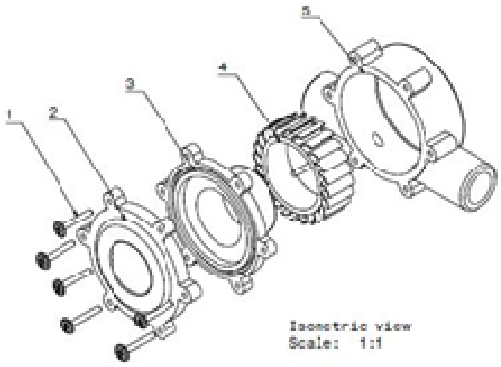


Figure 4: Pelton Wheel (Runner) (1. Bolt, 2. Cover, 3. Generator, 4. Runner, 5. Casing).

Reaction generators (Crossflow) are those sorts of generators with which the diploma of response does now not same 0, and the primary of stress drop takes region within the rotating wheel (in impulse turbine, the pressure drop takes place within the nozzle) [4].

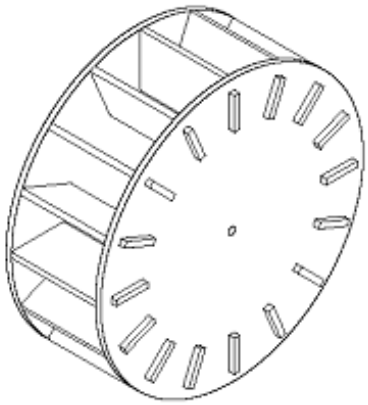


Figure 5: Crossflow Runner.

MHPP characteristics depends on moment, torque, water velocity, runner speed, water flowrate, dimension of the runner, number of blades, and power generated by MHPP [1].

How does the MHPP work? The water from water resources (dam or tank) pumps and flows through the pipe and nozzle and then the water strikes the blades (velocity triangles theory and lift and drag) and then rotates the runner and generator using specific transmission.

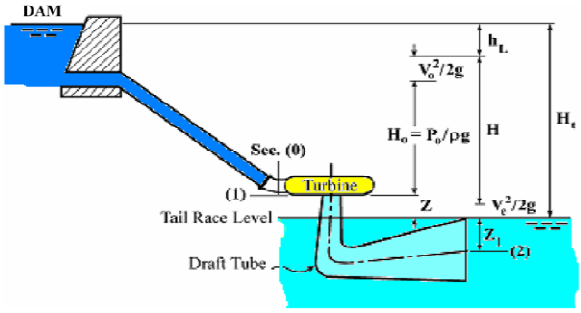
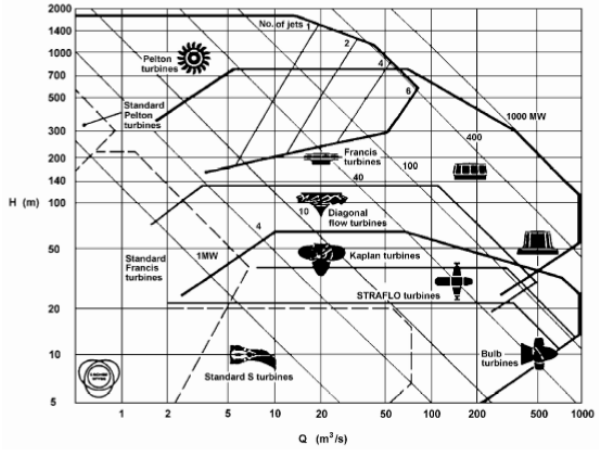


Figure 6: Diagram MHPP [4].



Source: [4].

Figure 6: Application Ranges of Different Types of Water Turbines.

The water flowrate is simulated by centrifugal pumps between 14 till 15 litre/minute and measured by *water flow meter*.

The power generated by MHPP is measured by digital multitester and the water flowrate is measured by water flow meter.

Power formula is:

$$P = V \cdot I \quad (1)$$

Where,

P = *power* [watt]

V= *voltage* [volt]

I = *Ampere* [ampere]

2.2. Simulation

Simulation is an activity that depends on exercising a model [8].

Simulation is a version of a hard and fast of problems or activities that may be used to train a person how to do something, or the manner of making the sort of version [7], [15].

Model is something that represents any other component, each as a bodily item and this is usually smaller than the real object, or as a simple description that may be utilized in calculations [7], [15]

The simulation objectives are: 1) To train the specific skills about lifestyle or human being professionally. 2) To get the conceptability. 3) To train solving the problems. 4) To increase the activities and motivate to learn. 5) To train the team work 6) To grow the creatitivity.

2.3. Strategy

Strategy is defined as a manner or plan selected to result in a desired destiny, including fulfillment of a motive or choice to a problem. Or technique is the art and science of making plans and marshalling sources for his or her maximum green and effective use. The term is derived from the Greek word for generalship or primary an military [6], [13], [14], [16].

Scenario is defined as a description of possible actions or events in the future [7].

3. RESEARCH METHOD

3.1. Experimental Design

This research used a quantitative approach – experimental design - *Two way anova*. The independent variable are turbine type (Pelton and crossflow) and the water flowrate. The dependent variable is power generated by MHPP using NACA 24012.

3.2. Mathematical Model

The formula of experimantal design - Two way anova [1], [5] is:

$$Yijk = \mu + WFi + TTj + WFTTij + \varepsilon k(ij) \quad (2)$$

where:

i = 1, 2, …, a; j = 1, 2, … , b; k = 1, 2, … , c

WF = Water flowrate [litre/minute]

TT = Turbine Type (Pelton and Crossflow)

WFTT = Interaction of water flowrate and turbine type

Yijk = Power generated by MHPP

3.3. Tests of Hypotheses

The null hypotheses are good sized if the approach of the variables facts aren't specific drastically at the extent five % and the possibility hypotheses are rejected if the way of the variables are high-quality appreciably at the extent 5% [1], [5].

3.4. Design Outline

The steps of the research [1] are:

- Experiment
  - Statement of the hassle
  - Choice of reaction or based variable

- Selection of things to be numerous
- Choice of degrees of those elements
- How component ranges are to be combined
  - Quantitative or qualitative techniques
  - Fixed or random

- Design
  - Number of observation to be taken
  - Order of experimentation
  - Method of randomization to be used
  - Mathematical model to describe the take a look
  - Hypotheses to be examined
- Analysis
  - Data Collection and processing
  - Computation of take a look at statistics
  - Interpretation of consequences for the experimenter.

4. RESULT AND ANALYSIS

4.1. Experimental Design

Table 2 shows the result of the experimentation data - the water flowrate variation between 14.1 to 14.6 litre/minute and the replication is ten data every cell.

4.2. Data Accumulation and Analysis

Figure 7 shows researchers set the MHPP simulation apparatus, simulate and data accumulation (Table 1).

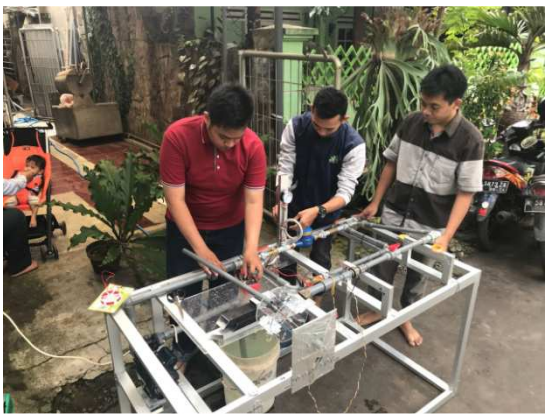


Figure 7: Set and Trials the Apparatus and Data Accumulation.

Table 1: Replication, Turbine Type, Flowrate, and Power

Replication	Turbine Type	Power [watt]			
		Q1	Q2	Q3	Q4
1	Crossflow NACA 24014	3,780	3,760	3,250	2,860
2		3,890	3,940	3,320	3,160
3		4,000	4,130	3,520	3,380
4		4,030	4,220	3,540	3,450
5		4,100	4,260	3,550	3,500
6		4,180	4,330	3,560	3,720
7		4,330	4,430	3,620	3,720
8		4,420	4,470	3,870	3,970
9		4,490	4,480	4,000	4,000
10		5,110	4,660	4,190	4,160
	Sum	37,220	38,020	29,850	29,900
	Mean	3,722	3,802	2,985	2,990
1	*Pelton*	1,162	1,160	1,159	1,153
2		1,162	1,160	1,160	1,155
3		1,163	1,161	1,161	1,157
4		1,164	1,162	1,162	1,158
5		1,165	1,162	1,163	1,158
6		1,165	1,163	1,164	1,158
7		1,168	1,164	1,164	1,158
8		1,168	1,165	1,164	1,158
9		1,168	1,165	1,165	1,159
10		1,168	1,166	1,165	1,160
	Sum	11,653	9,297	8,133	9,254
	Mean	1,165	0,930	0,813	0,925
	Total	48,873	47,317	37,983	39,154
	Average	2,444	2,366	1,899	1,958

Notes:
Q1 = 14.6 [litre/minute]
Q2 = 14.5 [litre/minute]
Q3 = 14.4 [litre/minute]
Q4 = 14.1 [litre/minute]

Table 2. Analysis of Variance [1], [5]

Source of variation	Degrees of Freedom	Sum of Squared	Mean Squared	Fratio	Ftable	Remark
Flowrate (A)	3	52,54	17,51	11,79	3,21	Rejected
Turbine Type (B)	1	186,55	186,55	125,62	4,08	Rejected
Interaction (AB)	3	66,29	22,10	14,88	3,21	Rejected
Error	72	106,92	1,49			
Total	79					

Table 2 shows the F ratio exceed F table, it means the null hypothesis is rejected or there is a different significantly at 5%.

Table 3: Water Flowrate, Turbine Type, and Power [watt]

Replication	Power [watt]							
	Crossflow				Pelton			
	Q11	Q12	Q13	Q14	Q21	Q22	Q23	Q24
1	3,780	3,760	3,250	2,860	1,162	1,160	1,159	1,153
2	3,890	3,940	3,320	3,160	1,162	1,160	1,160	1,155
3	4,000	4,130	3,520	3,380	1,163	1,161	1,161	1,157
4	4,030	4,220	3,540	3,450	1,164	1,162	1,162	1,158
5	4,100	4,260	3,550	3,500	1,165	1,162	1,163	1,158
6	4,180	4,330	3,560	3,720	1,165	1,163	1,164	1,158
7	4,330	4,430	3,620	3,720	1,168	1,164	1,164	1,158
8	4,420	4,470	3,870	3,970	1,168	1,165	1,164	1,158
9	4,490	4,480	4,000	4,000	1,168	1,165	1,165	1,159
10	5,110	4,660	4,190	4,160	1,168	1,166	1,165	1,160
Mean	4,233	4,268	3,642	3,592	1,165	1,163	1,163	1,157
Standard of deviation	0,383	0,270	0,294	0,403	0,003	0,002	0,002	0,002

Notes:
Q11 = 14.6 [litre/minute]
Q12 = 14.5 [litre/minute]
Q13 = 14.4 [litre/minute]
Q14 = 14.1 [litre/minute]
Q21 = 14.6 [litre/minute]
Q22 = 14.5 [litre/minute]
Q23 = 14.4 [litre/minute]
Q24 = 14.1 [litre/minute]

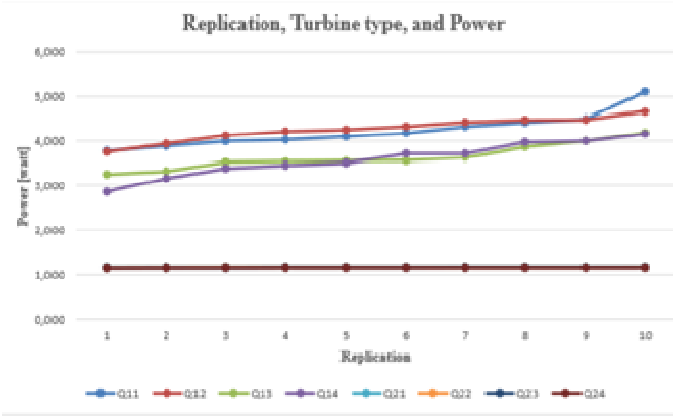


Figure 8: Replication, Turbine Type, Power, and Water Flow Rate.

Table 4 and Figure 8 show the situation and the parameters of the method improvement - the usage of turbine type, water goes with the flow charge and electricity generated via MHPP are

The maximum and minimum power generated with the resource of MHPP uses cross flow kind, the water flow rate is 14. 5 [litre/minute] and 14.1 [litre/minute], and the common energy generated by way of manner of MHPP is 4.628 [watt], and 3.592 [watt] respectively.

The maximum and minimum power generated by MHPP uses Pelton type, the water flowrate is 14.6 [litre/minute] and 14.1 [litre/minute]. And the common power generated by way of MHPP is 1. A 165 [watt], and 1.157 [watt] respectively

Table 4: The Strategy Development

No	Strategy	Alternatives
1	Scenario 1	The most electricity generated thru MHPP - the usage of cross flow kind, the water flow rate is 14.5 [litre/minute], and the common electricity generated with the aid of MHPP is 4.628 [watt].
2	Scenario 2	The minimum power generated with the resource of MHPP - the usage of cross flow type, the water flow rate is 14.1 [litre/minute], and the commonplace strength generated by means of way of MHPP is 3.592 [watt].
3	Scenario 3	The most electricity generated through MHPP - the usage of Pelton type, the water flow rate is 14.6 [litre/minute], and the average power generated via MHPP is 1.A 16 5 [watt].
4	Scenario 4	The minimum strength generated with the aid of MHPP the use of Pelton type, the water flow rate is 14.1 [litre/minute], and the not unusual power generated through MHPP is 1.157 [watt].

5. CONCLUSIONS

The F ratio exceeds F table, its technique, the null hypothesis is rejected or there may be a one-of-a-type drastically at 5%.

The technique for selecting the energy is the maximum and minimal energy generated by using manner of MHPP using crossflow type, the water flowrate is 14.5 [litre/minute] and 14.1 [litre/minute], and the commonplace power generated by way of the use of MHPP is 4.628 [watt], and 3.592 [watt] respectively. And The most and minimum power generated through way of MHPP used Pelton type, the water flowrate is 14.6 [litre/minute] and 14.1 [litre/minute], and the not unusual strength generated by using MHPP is 1. 16 5 [watt], and 1.157 [watt] respectively.

6. ACKNOWLEDGEMENT

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